The Role of Phonological Awareness and Phonetic Radical Awareness in Acquiring Chinese Character Literacy Skills in Learners of Chinese as a Second Language

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Abstract

There is much research into the roles of phonological awareness and phonetic radical awareness in the development of Chinese character reading and writing skills in native-speaking children, but there is comparatively little work on the relationship between such metalinguistic skills and character literacy skills in adult learners of Chinese a second language (CSL). In this study, we explored this issue with 83 Arabic and English CSL learners who had studied Chinese in their home country. Their knowledge of phonological awareness, phonetic radical awareness, and Chinese character reading and writing was measured. There were two main findings. Firstly, the learners' phonological awareness, but not their phonetic radical awareness, predicted the acquisition of character reading and writing skills directly or indirectly, in line with previous research (Everson, 1998; Jiang, 2003). Secondly, contrary to earlier findings, phonetic radical awareness did not mediate the effect of phonological awareness on character reading and writing skills (Tong & Yip, 2014). The results point to the different roles that phonological awareness and phonetic radical awareness play in the development of character literacy skills, and the still unclear relationship between phonological awareness and phonetic radical awareness. These findings are important for understanding the contribution of phonological awareness and phonetic radical awareness to the acquisition of character literacy skills for CSL learners.

Keywords: second language acquisition, phonological awareness, phonetic radical awareness, Chinese character, metalinguistic awareness

1. Introduction

Phonological and phonetic metalinguistic skills have been found to have an impact on the development of literacy skills in general. The importance of phonological awareness for users of alphabetic writing systems (e.g. English), and both phonological and phonetic radical awareness for the acquisition of morphosyllabic orthography (e.g. Chinese), have been well-documented in native speaking children, but there has been very little work on learners of Chinese as a second language (CSL). In the current study, we investigate the impact of these metalinguistic skills on the acquisition of Chinese character literacy skills in adult CSL learners, whose first language (L1) is either English or Arabic, both of which differ a great deal from Chinese in their phonological and orthographic properties. Before reporting the details of the experiment, in the following sections we first set out the relevant background to the study, covering the topics of phonological awareness and phonetic radical awareness and literacy acquisition in native speaking children and adult L2 learners, in order to identify the research gaps in the field that this study aims to address.

1.1 Phonological awareness, phonetic radical awareness and literacy development in Children

Reading

Phonological metalinguistic skills are important for the acquisition of literacy skills for learners of both alphabetic and morphosyllabic writing systems, as proposed in several theoretical models of reading and spelling, such as the Universal Phonological Principle (Perfetti, 2003), the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005) and the Obligatory Phonological Mediation Hypothesis in Spelling (Rapp & Caramazza, 1997). For instance, Perfetti (2003) claims that “reading universally requires the reader to make links to language at the phonological and morphemic levels” (p.3). At the phonological level, phonological awareness - the awareness of the phonological structure of spoken words and the

ability to access and manipulate phonological structure (Saiegh-Haddad, 2017) - has been widely investigated. Ziegler and Goswami (2005) propose that phonological awareness is a crucial form of metalinguistic awareness competency for the growth of literacy skills across different languages. The close relationship between phonological awareness and literacy skills has been widely acknowledged in English (Bradley & Bryant, 1983; Goswami & Bryant, 2016; Hulme & Snowling, 2013; Swanson, Trainin, Necoechea, & Hammill, 2003; Ziegler et al., 2010). The importance of phonological awareness lies in the fact that it has been found to predict reading ability among native speaking children: better phonological awareness leads to easier access to the rudimentary phonological units of a language, which in turn makes the learning of orthography-phonology mapping possible and efficient. Two meta-analytic studies have explored the effect size of phonological awareness on English word reading skills among English-speaking children (Bus & Van, 1999; Swanson et al., 2003). Bus & Van reported that phonological awareness accounted for approximately 12% of the variance in English word recognition and Swanson et al. found that the correlation between phonological awareness and English real-word reading was moderate (r=.51). More supporting evidence for the important role of phonological awareness in acquiring reading skills has also been reported in abjad Arabic (Al Ghanem & Kearns, 2014).

Relevant to the current study, phonological awareness is also important for the acquisition of word reading skills for child learners of morphosyllabic writing systems such as Chinese, but to a lesser extent than for learners of alphabetic systems. That is, although significant correlations between phonological awareness and character reading performance have been observed among Chinese or Cantonese-speaking children (e.g. Chung, McBride, Cheung, & Wong, 2013; Huang & Hanley, 1995; McBride et al., 2008; Siok & Fletcher, 2001; So & Siegel, 1997), these have been found to be relatively weak, as shown by a recent meta-analysis study reporting a weak effect size of phonological awareness in character reading in native Chinese

speakers (*r*=.36) (Song, Georgiou, Su, & Shu, 2015). The weaker correlation between phonological awareness and character reading, in comparison to that in phoneme-based English, is perhaps explained by the orthographic characteristics of morphosyllabic characters, whose orthography-phonology mapping works at the syllable level. Nevertheless, these findings are consistent with the Universal Phonological Principle (Perfetti, 2003) and Psycholinguistic grainsize theory (Ziegler and Goswami, 2005), in which the role of phonological awareness in reading skills is assumed to be persistent but vary across the nature of the writing systems and the orthographies.

Another reason for differences noted above that have been found with regards to the importance of phonological awareness on literacy skills for alphabetic versus character reading is likely to be that, unlike for alphabetic systems, *phonetic radical* awareness plays an important part in the development of Chinese literacy. Phonetic radicals relate to the phonological information which may be contained in syllabic Chinese characters. Specifically, the Chinese character writing system is morphosyllabic which can be categorized into single characters such as 女, 子 and compound characters, such as 好. Although there is no direct mapping between phonology and orthography in Chinese characters, most compounds contain both phonological (phonetic radicals), and semantic cues in the form of semantic radicals. Take 清 (qīng, clear, clean) for example, the left part 氵 (shuǐ, water) is a semantic radical implying that 清 is related to water, and the right part 青 (qīng) is a phonological radical cueing the phonological information of 清. Most phonetic radicals appear on the right-hand side, and semantic radical on the left-hand side.

Phonetic radical awareness, the knowledge of and the ability to manipulate the functional and positional information of phonetic radicals, is therefore clearly another important type of metalinguistic processing skill in character recognition for native Chinese speakers (Shu,

Anderson, & Wu, 2000). This is because the phonteic radical is the only orthographic unit that can provide phonological cues for a character, and thus is required for retrieving its phonological representation. Evidence for the importance of phonetic radical awareness comes from several studies which have investigated the correlation between phonetic radical awareness and character recognition skills. For instance, Ho, Ng and Ng (2003) used three tasks to measure children's knowledge of phonetic radicals: a radical position judgment task, a phonological-relatedness judgment task and a pseudo-character naming task. The phonological-relatedness judgment and pseudo-character naming tasks, not radical position judgment task, significantly associated with Chinese word reading skills. Studies have found a significant relationship between general radical position awareness and character reading skills (Luo, Chen, Deacon & Li, 2011), and that children's sensitivity to the functional and positional properties of phonetic radicals explained unique variances in Chinese word reading skills tested one year later (Yin & McBride, 2015). These results point to the significant relationship between phonetic radical awareness and character recognition skills.

As regards the relationship between phonological awareness and phonetic radical awareness in Chinese reading development, it has been suggested that the former is mediated by the latter. That is, the function of phonological awareness in aiding character recognition is assumed to be bridged by phonetic radical awareness skills (Ho & Bryant, 1997a, 1997b). Support for this assumption comes from studies with Chinese children. For instance, Ho & Bryant (1997b) administered a rhyme-tone detection task to measure phonological awareness and pseudo-character reading to examine phonetic radical awareness among Hong Kong kindergartners. When pseudo-character reading was controlled for, the children's performance in character reading was strongly predicted by rhyme-tone detection ability, yet its predictive power appeared weaker compared with that when pseudo-character reading was not entered. Another study by Ho and Bryant (1997a) in Hong Kong children found that the significant

relationship between rhyme detection and character reading scores disappeared in their regression model when the pseudo-character reading ability was entered. On the basis of these results, the researchers argue that "at least to some extent, the link between phonological skills and reading Chinese is through the use of the character's phonetic component in reading" (p.950).

Writing

Turning to spelling skills, the strong association between phonological awareness and spelling ability in alphabetic orthographies has been documented in numerous cross-language studies. It has been widely recognized that phonological awareness is one of the core components underlying the development of spelling skills in different alphabetic languages, such as Czech, English and French (Caravolas, 2004). For example, performance on phonological awareness tasks accounted for significant amounts (4.1% - 8.9%) of the variances in spelling scores in English, German, Hungarian and Finnish (Moll et al., 2014). The strong link between phonological awareness and spelling skills has also been observed in studies of Arabic speakers (al Mannai & Everatt, 2005). In contrast, phonological awareness appears not to be a key metalinguistic skill for character writing development in children. For example, phonological awareness, among other cognitive skills, in character writing among Chinese-speaking children in Hong Kong did not significantly predict their writing performance (Liu, Chen & Wang, 2016; Yeung et al., 2011). Instead, orthographic skills, morphological awareness (Yeung et al., 2011) and visual-spatial skills (Liu, Chen & Wang, 2016) played a greater role in explaining variance in character writing.

The contribution of phonetic radical awareness to character writing has been documented in a study by Yin and McBride (2015), who examined the relationship between sensitivity to phonetic radical and character writing skills in kindergarteners in Beijing. They measured the

children's sensitivity to phonetic radicals by asking them to learn three types of character: random strokes, non-character and pseudo-characters. Both the non-character and pseudo-characters were displayed in the condition with a phonetic cue (the phonetic radical corresponded to the pronunciation of character) and the condition without a phonetic cue (the phonetic radical did not correspond to the pronunciation of character). The children's achievement in learning pseudo-characters without phonetic cues, examining the children's positional awareness of the phonetic radical, accounted for a remarkable amount of unique variance (4%) in character writing, indicating the unique relationship between phonetic radical awareness and character writing ability.

In sum, the studies mentioned above suggest that for child literacy development in the L1, phonological awareness is important for the development of reading skills across different writing systems, yet it appears to be more critical for spelling skills in an alphabetic than a morphosyllabic orthography, in which phonetic radical awareness is key. Below we set out research on L2 phonological awareness, phonetic radical awareness and literacy development.

1.2 Phonological awareness, phonetic radical awareness and L2 literacy development

Reading

In comparison to the work on literacy development in native-speaking children, there is much less research examining the association between phonological awareness and reading skills for L2 learners in general, and particularly in L2 Chinese. Most work has focused on (often child) L2 English, and the findings are comparable to those on children reported above, reporting a link between phonological awareness and reading ability, as observed among Cantonese, Mandarin, Spanish and Portuguese L2 learners (Gottardo, Pasquarella, Chen, & Ramirez, 2015; McBride & Kail, 2002; Zhao, 2011). However, there is some evidence of L1

influence in the findings. For instance, Gottardo et al. (2015) found that phonological awareness significantly predicted the performance in English word reading both concurrently and longitudinally among young L2 learners who spoke Chinese, Spanish or Portuguese as an L1, but that word-reading accuracy was more strongly affected by phonological awareness skills in the learners from an alphabetic L1 than in the Chinese learners' performance.

To the best of our knowledge, few studies have explored the relationship between phonological awareness and Chinese character reading skills among CSL learners. However, available evidence shows that L1 background may influence the relationship between phonological processing skills and character reading skills (Everson, 1998; Jiang, 2003). A significant relationship between being able to pronounce and being able to identify Chinese characters has been observed only among the CSL learners speaking alphabetic L1s, not in Japanese and Korean learners whose L1 writing systems also utilize Chinese characters. For instance, Jiang (2003) concluded that CSL learners with a no-character background might rely on the phonological route to retrieve a character's meaning, being influenced by the phonological nature of their L1 orthographies, whereas L2 learners from a character background possibly depend more on the orthographic route to access the semantics of the character.

The results observed in the L2 learners of English and Chinese described above suggest that the relationship between phonological processing skills and L2 reading skills may be influenced by the typological distance between the L1 and the L2, as implied in Transfer Facilitation Model (Koda, 2008) and the NCCP (non-native Chinese character processing) model (Tong, Kwan, Wong, Lee, & Yip, 2015), however research is rather scarce, and no study has examined Chinese literacy development in adult L2 learners from an Arabic-speaking background. In the current study we address this research gap and examine the relationship

between phonological awareness and character reading skills in Arabic and English speaking CSL learners.

Turning to phonetic radical awareness, similar to what has been found for native Chinese children, CSL learners' sensitivity to the functional and positional information of radicals in character develops soon after being exposed to character instruction. Studies have found that English-speaking CSL learners may rapidly demonstrate senstivity to the orthographic structure of characters within a short period of Chinese learning. For isntance, participants tend to show longer reaction times and lower accuracy rates in judging pseudo characters with legal radicals in legal positions in comparison to those with legal radicals in illegal positions or those with illegal radicals (Wang, Perfetti & Liu, 2003; Wang, Liu & Perfetti, 2004), or to choose the pseudo-character in the correct phonetic position picture-character mapping (Tong &Yip, 2014). Similar findings have been reported in Vietnamese-speaking CSL learners using the task of delayed copying (Nguyen, Li, Wu, & Sun, 2016).

Radical awareness may in fact be a unique predictor in CSL learners' character reading performance (Wong, 2017). Further support for this comes from Tong and Yip (2014) who found that 19%-24% of variance of recognition performance in reading single character and two-character words were accounted for by phonetic radical sensitivity. Thus the small but available evidence points to a significant contribution of phonetic radical awareness to character recognition skills for CSL learners. Tong et al. (2015) proposed an NCCP model which particularly emphasizes the specific characteristics of characters, in which both the semantically-driven and phonetically-driven pathways are crucial for the success in reading characters. However, whether phonetic radical awareness mediates the function of phonological awareness in facilitating character reading skills in CSL learners has yet to be explored.

Writing

Consistent with findings for native English speakers, phonological awareness is also a significnat predictor of English spelling skills among ESL learners. For ESL children, their knowledge of phonological awareness significantly correlated with their spelling scores (de Sousa, Greenop & Fry, 2010) or free-writing (He & Wang, 2009), accounting for up to 24% of the variance in their spelling performance (Jongejan, Verhoeven and Siegel, 2007). Further research reveals the influence of L1 background on the relationship between phonological awareness and L2 spelling skills. For instance, Zhao, Joshi, Dixon and Chen (2017) found that the effect size of phonological awareness on English word spelling in Chinese ESL children was smaller than that found for the native English-speaking children. This was attributed to the influence of morphosyllabic characters in Chinese ESL learners' L1, leading them to rely more heavily on orthographic information for character reading.

How phonological awarenss and phonetic radical awareness contribute to character writing among CSL learners has been uninvestigated to our knowledge. Therefore, the current study attempts to fill this gap by exploring the relationship between CSL learners' knowledge of phonological awareness, phonetic radical awareness and their performance in writing Chinese characters.

2. The current study

As described above, although there is a large amount of literature documenting the role of phonological awareness and phonetic radical awareness in users of morphosyllabic orthography, we are aware of no study that has yet explored the contribution of these two types of metalinguistic awareness competencies to character literacy skills among CSL learners speaking alphabetic L1s such as Arabic and English. In addition, more work explored the role

of semantic radical awareness and meaning-related skills than on phonetic radical awareness and decoding skills. Moreover, most studies focus on character reading skill and the relative cognitive factors, with little attention to how these factors contribute to character writing. Meanwhile, whether phonetic radical awareness mediates the relationship between phonological awareness and character literacy skills is still unclear. Therefore, this study has two purposes, leading to two research questions.

RQ1. How do the metalinguistic skills of phonological awareness and phonetic radical awareness contribute to the acquisition of Chinese character reading and writing skills among Arabic and English CSL learners?

Arabic and English are phoneme-based languages, thus the Arabic and English CSL learners are hypothesized to rely on phonological processing skills to access character, and the relationship between phonological awareness and character literacy skills might be stronger than that between phonetic radical awareness and character literacy skills.

RQ 2. Is phonological awareness mediated by phonetic radical awareness in CLS learners' Chinese character reading and writing skills?

Since the phonetic radical is the only orthographic component that carries phonological information in a character, it is hypothesized to bridge the function of phonological awareness in character literacy skills in adult L2 learners.

3. Method

3.1 Participants

Eighty-three Arabic and English L2 learners of Chinese took part in this study (Table 1). All were living in their native countries (Egypt and the UK) and studying Chinese as a major

subject at university. The participants were recruited from the 2nd-year and the 3rd-year learners, who had studied Chinese for about one and two years, respectively.

The Arabic participants learned Chinese for approximately 20 hours per week, and did not have experience of study abroad in a Chinese-speaking context. The Arabic speakers had learned English before starting to learn Chinese because of the course policy in their high school, yet their English language proficiency was pre-intermediate, as reported by their Chinese teachers. The mainstream textbooks used by Arabic groups were *Boya Hanyu* (Li, 2004) which is widely used in the Confucius Institute abroad. In Egypt, Pinyin is taught prior to character learning, and characters are taught with the aid of Pinyin.

Table 1 Demographic information of the Arabic and English L2 Participants

		Arabic	English	Total
N		43	40	83
Gender	Female	39	23	62
	Male	4	17	21
Academic year	2nd year	23	20	43
	3rd year	20	20	40
Age (SD)		19.58(.79)	20.55(1.32)	20.05(1.18)
HSK scores (SD)		9(3.59)	9.97(3.43)	9.47(3.52)
Years of stay in China		0	.84(1.41)	.40(1.06)

In the UK, the English group studied Chinese as a major subject. The 3rd-year group had studied abroad in China for one year due to their course policy, and the 2nd-year group did not have a study abroad experience. The 2nd-year group studied Chinese for about ten hours per week, and the 3rd-year group learned Chinese for about 20 hours per week when in China. The textbooks used by the 2nd-year group were *Chinese in Steps* (Zhang & Li, 2006), which targets the CSL learners at the universities in the UK. The 3rd-year group used a variety of textbooks when in China. As with the Arabic learners, Pinyin is introduced before character learning,

which is acquired with the help of Pinyin.

In an attempt to ensure that the two L2 groups were as comparable as possible, the participants' proficiency was measured using the standardized HSK (Hanyu Shuiping Kaoshi) test, including 16 questions, half from pre-intermediate level and half from intermediate level. The test comprises listening and reading comprehension components, each of which including 8 questions. It was administered as a paper-and-pencil test, and took approximately 20 minutes. One score was assigned to one correct answer, and zero score to one incorrect answer or unanswered question. The maximum score was 16. The Cronbach's alpha reliability of the HSK test was .80. The two groups did not differ significantly in HSK scores, $t(81)=-1.26$, $p=.21$, Cohen's d=.28, Hedge's g=.28, suggesting that they were matched in Chinese proficiency.

3.2 Measures

To address our two research questions, the metalinguistic knowledge of the participants on Chinese phonological awareness and phonetic radical awareness were tested via an oddity task and a pseudo-character naming task. To examine the association between the learners' performance on the two metalinguistic tasks and their literacy skills, a Chinese character reading task and a character writing task were employed. The details of each of the four tasks are set out below.

Chinese phonological awareness: the Oddity Task

There is no available standard test for Chinese phonological awareness, thus an oddity task, the most popular form for tapping phonological awareness, was designed. The test included four subtests comprising 8 items each, which explored syllable, onset, rime and tone awareness, respectively. It was a paper-and-pencil task, and the participants were required to listen to a set of three items, and to then detect the odd one out on a provided sheet. For example,

among “dàgē, xiàngpí, gēmí”, the odd one was “xiàngpí,” because the other two words have the same syllable “gē”.

All the stimuli in the oddity test were selected from *The Graded Chinese Syllables, Characters and Words for the Application of Teaching Chinese to the Speakers of Other Languages* (Guojia yuwei, 2010) and were recorded by an adult female native Chinese speaker in a professional sound-proof language lab. The accuracy rate of phonological awareness test was calculated by dividing the number of correct answers by 32. The Cronbach’s alpha reliability of phonological awareness test was .72.

Phonetic radical awareness: the Pseudo-Character Naming Task

Phonetic radical awareness has been examined using pseudo-character naming tasks in previous research, however there is no consensus about the exact nature of the pseudo-characters that should be employed (Ho & Bryant, 1997b; Ho et al., 2003; Tong & Yip, 2014). Therefore, to examine the participants’ phonetic radical awareness, a pseudo-character naming task was developed basing on the L2 participants’ Chinese proficiency. The aim was to investigate the L2 learners' overall knowledge of the function and position of phonetic radicals in reading semantic-phonetic characters. In this task, the participants were required to write down the pronunciations of 10 pseudo-characters using Pinyin. Each pseudo-character was constructed as left-right structure formed by a pair of single characters. Ten frequent single characters that can be used as phonetic radicals in compound characters were selected. Two of the ten characters frequently occur in the top position as phonetic radicals, and the other eight are commonly used in left-right structured characters. In terms of regularity and neighborhood consistency, five characters had relatively strong regularity and consistency such as 中(zhōng) in 种(zhǒng),钟(zhōng), 肿(zhǒng) and 主(zhǔ) in 注(zhù),住(zhù),柱(zhù), and the other

five demonstrated poor regularity and consistency such as 力(lì) in 穷(qióng), 劳(láo), 边(biān) and 不(bù) in 坏(huài), 杯(bēi), 歪(wāi). The mean accuracy rate in reading the ten single characters was .89 (SD=.02, min=.50, max=1.00) in the Arabic group and .88 (SD=.09, min=.60, max=1.00) in the English group, respectively. The Arabic and English CSL groups did not differ significantly in reading the single characters, $t(82)=.41$, $p=.69$.

Each pair of single characters was selected randomly to construct two pseudo-characters that differed only in the positions of the radicals. Take 不 (bù, not) and 力 (lì, power) for example; they were used to construct two pseudo-characters  and  . In addition to the pseudo-character, five real characters with low frequency were added as distractors. The time limit for this task was five minutes. The participants' use of right-side single character to name the pseudo-character was analyzed, as a majority of phonetic radicals appear on the right side in compound characters. For instance, the right-side character could be used directly to name the pseudo-character, termed as direct naming strategy, such as naming  as 也 <yě>. In addition, another character with similar orthographic features as the right-side character might be utilized to name the pseudo-character, labelled as similar character naming strategy, such as  might be named as 王 <wáng>. Moreover, another character containing the right-side character in the pseudo-character might be used to name the pseudo-character, called family character naming strategy, such as naming  as < tā > (他 or 她). The participants' performance in phonetic radical awareness was calculated by dividing the frequency of these three types of responses by 10.

Considering this task was new, we piloted this task among 22 native Chinese university students (mean age=27.18, SD=4.98; male=10, female=12). The percentage of using the right-side character in this task was .69 (SD=.20), which was significantly above chance level ($t(21)=.4.46$, $p=.0002$). The results were in line with the dominant status of right-side phonetic

radicalss in modern character and the common practice of using the right-side phonetic radical to name unfamiliar characters among the native Chinese speakers. The pilot results indicate the validity of this task to explore phonetic radical awareness.

Character reading

The task of reading characters for pronunciation included 108 semantic-phonetic characters (Table 2). The selected characters were balanced in regularity and position of the phonetic radicals. In terms of the regularity of the phonetic radical, three types of semantic-phonetic character (regular, semiregular and irregular) were included, with 36 characters for each type. In terms of the position of the phonetic radicals, two types of character were included. One type was character with phonetic radical on the right side and another type was that with phonetic radical on the left side, with 54 characters for each type. All the characters were selected from *The Graded Chinese Syllables, Characters and Words for the Application of Teaching Chinese to the Speakers of Other Languages* (Guojia yuwei, 2010), and they were balanced in frequency and the number of stroke (Institute of Big Data and Language Education, 2011). ANOVA tests showed that neither the three types of character with different degrees of regularity nor the two types of character with different positional structures differed in the stroke number or the frequency.

The selected characters were printed on one A4 sheet of paper and arranged from high to low frequency. The participants were required to read aloud the characters according to the numeric order. If they did not know, they were required to say "I don't know". One common practice in examining character recognition skills among native Chinese-speaking children is that the test stops when the participant makes 10 or 15 errors consecutively (Ho & Bryant, 1997a; Li, Shu, McBride-Chang, Liu, & Peng, 2012; Lin, Sun, & Zhang, 2016; Luo, Chen, Deacon, Zhang, & Yin, 2013; McBride-Chang, Cheung, Chow, Chow, & Choi, 2006; Tong,

2008). However, native Chinese-speaking children and CSL learners differ greatly in recognition skills because the required number of characters to be recognized for intermediate CSL learners is 1800 (Guojia yuwei, 2010) and the Chinese children at 4th grade are required to recognize up to 2500 characters (Ministry of Education of the People's Republic of China, 2001). Considering the CSL participants' relatively low proficiency in character recognition, the test stopped if the participant made five errors or did not respond to five characters in a row in this study. The time limit was three minutes. Considering the great challenge of pronouncing correct tones for the CSL learners, tone was not included in the analysis criterion. One score was given if the syllable was pronounced correct, and 0 if the pronounced syllable was wrong or missed. The accuracy rate in character reading was calculated by dividing the number of accurate answers by 108. The Cronbach's alpha reliability of character reading was .93.

Table 2 Details of the selected characters in the task of reading

Type		Example	*N*	Stroke number (*SD*)	Frequency (*SD*)
Regularity	Regular	理	36	9.53 (2.77)	.0002 (.0002)
	Semiregular	放	36	9.57 (2.50)	.0002 (.0003)
	Irregular	她	36	9.03 (2.51)	.0005 (.0015)
Position	LPR	放	54	9.63(2.92)	.0002(.0002)
	RPR	理	54	9.11(2.18)	.0004(.0013)

Note. LPR = left-side phonetic radical; RPR = right-side phonetic radical

Character writing

The task of character writing included 24 characters (different from those in the reading task) which were balanced in the regularity and position of the phonetic radicals (Table 3). Three types of semantic-phonetic characters (regular, semiregular and irregular) were included,

with 8 characters for each type. In terms of the position of the phonetic radical, two types of characters were included, and there were 12 LPR and 12 RPR characters. All these characters were selected from *The Graded Chinese Syllables, Characters and Words for the Application of Teaching Chinese to the Speakers of Other Languages*, and balanced in frequency and the number of stroke. ANOVA tests showed that neither the three types of characters with different degrees of regularity nor the two types of characters with different positional structures differed in the stroke number or the frequency. This task was measured using a paper-and-pencil test. The participants were required to write the target character according to the displayed words in Pinyin and the translation. For instance, the target character for ***dōu*** lái le (all came) is 都. One score was given to a correct answer, and zero to a wrong answer or unanswered item. The accuracy rate was calculated by dividing the number of correct answers by 24. The Cronbach's alpha reliability of character writing was .80.

Table 3 Details of the selected characters in the task of writing

Type		Example	*N*	Stroke number (*SD*)	Frequency (*SD*)
Regularity	Regular	但	8	8.00(1.31)	.0004(.0007)
	Semiregular	此	8	8.00(1.51)	.0004(.0005)
	Irregular	都	8	9.13(1.46)	.0005(.0009)
Position	LPR	此	12	8.08(1.62)	.0005(.0008)
	RPR	但	12	8.67(1.30)	.0003(.0006)

Note. LPR = left-side phonetic radical; RPR = right-side phonetic radical

3.3 Procedure

The instructions of the tests were translated into English or Arabic by two native speakers

who majored in second language acquisition. All the participants were tested individually and were given a small amount of money after successfully completing the tests.

4. Results

Before analyzing the data in order to address our two research questions, the participants' overall performance on all four tasks were analyzed (Table 4). It can be seen that the two groups achieved similar accuracy scores in phonetic radical awareness, character reading and character writing. The English group outperformed the Arabic group in phonological awareness, yet each group's performance was above the chance level (Arabic, $t(43)=14.47$, $p<.0001$; English, $t(39)=29.25$, $p<.0001$). The correlation matrix between the measured variables is presented in Table 5. It could be seen that phonological awareness only significantly correlated with character reading ($r=.30$, $p<.01$) in the pooled group, and that phonetic radical awareness did not significantly correlate with character reading or character writing.

4.1 RQ 1. How do the metalinguistic skills of phonological awareness and phonetic radical awareness contribute to the acquisition of Chinese character reading and writing skills among Arabic and English CSL learners?

Table 4 Summary of the participants' performances in phonological awareness, phonetic radical awareness, character reading and character writing

	Arabic		English		Total		Group difference			
Measures	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*	*g*
Phonological awareness	.74	.11	.87	.08	.80	.12	-6.1	<.001	1.33	1.31
Phonetic radical awareness	.38	.33	.53	.37	.45	.36	-1.90	.07	.42	.42
character reading	.21	.12	.27	.16	.24	.14	-1.85	.07	.41	.41
character writing	.30	.16	.25	.15	.28	.16	1.33	.19	.29	.29

Table 5 Correlation matrix between phonological awareness, phonetic radical awareness, character reading and character writing

Group		PA	PRA	reading	writing
English	PA	1.00			
	PRA	.06	1.00		
	reading	.17	.29	1.00	
	writing	.19	.05	.78*	1.00
Arabic	PA	1.00			
	PRA	.03	1.00		
	reading	.30	-.11	1.00	
	writing	.25	-.10	.77*	1.00
English + Arabic	PA	1.00			
	PRA	0.15	1.00		
	reading	0.30**	0.16	1.00	
	writing	0.10	-.05	0.71***	1.00

Note. PA=phonological awareness, PRA=phonetic radical awareness. *p<.05, **p<.01, ***p<.001

Research question 1 involves the investigation of the role of phonological awareness and phonetic radical awareness in character reading and writing skills among the Arabic and English CSL learners, and therefore a series of hierarchical regressions were performed to examine the extent to which scores on the two metalinguistic tasks were associated with character reading and writing skills. Firstly reading skill performance is analysed (Table 6), then writing ability is focused on (Table 7).

Table 6 Regression models predicting character reading skills

Steps	Predictor	Model 1			Model 2			Model 3		
		B	SE	β	B	SE	β	B	SE	β
1	Age	0.01	0.01	.06	0.01	0.01	.09	0.01	0.01	0.09
	Gender	0.06	0.04	.19	0.05	0.04	.15	0.05	0.04	0.16
	China years	-0.02	0.02	-.11	-0.01	0.02	-.08	-0.01	0.02	-0.08
	L1	0.04	0.04	.15	0.00	0.04	.01	-0.00	0.04	-0.02
2	PA				0.29	0.16	.24	0.29	0.16	0.23
3	PRA							0.05	0.04	0.13
R^2			.08			.12			.13	
Adjusted R^2			.04			.06			.07	
F for change in R^2			--			3.15			1.29	
1	Age	0.01	0.01	.06	0.01	0.01	.07	0.01	0.01	0.09
	Gender	0.06	0.04	.19	0.07	0.04	.20	0.05	0.04	0.16
	China years	-0.02	0.02	-.11	-0.01	0.02	-.11	-0.01	0.02	-0.08
	L1	0.04	0.04	.15	0.03	0.04	.11	-0.00	0.04	-0.02
2	PRA				0.05	0.04	.13	0.05	0.04	0.13
3	PA							0.29	0.16	0.23
R^2			.08			.10			.13	
Adjusted R^2			.04			.04			.07	
F for change in R^2			--			1.51			3.02	

Note. PA=phonological awareness, PRA=phonetic radical awareness.

Character reading (Table 6). The first step was the same as involved in the regressions, with age, gender, length of stay in China and L1 background entered. Phonological awareness and phonetic radical awareness were entered in steps 2-3 in different orders. As shown in Table 6, the variables in the first step accounted for 8% of the variance in character reading skills. When phonological awareness was entered in step 2 and phonetic radical awareness in step 3, each accounted for 4% and 1% of the variance in character reading skills, respectively. When phonetic radical awareness was entered in step 2 and phonological awareness in step 3, each

explained 2% and 3% of the variance in character reading skills, respectively. Further examination of regression coefficients showed that the contribution of phonological awareness to character reading was marginally significant (p=.07).

Table 7 Regression models predicting character writing skills

Steps	Predictor	Model 1			Model 2			Model 3		
		B	SE	β	B	SE	β	B	SE	β
1	Age	0	0.02	-.02	0	0.02	0	0	0.02	0
	Gender	0.09*	0.04	.24	0.07	0.04	.20	0.07	0.04	.20
	China years	-0.01	0.02	-.10	-0.01	0.02	-.07	-0.01	0.02	-.07
	L1	-0.06	0.04	-.19	-0.10	0.05	-.32	-0.10	0.05	-.32*
2	PA				0.30	0.18	.22	0.30	0.18	.22
3	PRA							-0.01	0.05	-.02
R^2			.07			.10			.10	
Adjusted R^2			.02			.05			.03	
F for change in R^2			--			2.73			.03	
1	Age	0	0.02	-.02	0	0.02	-.02	0	0.02	0
	Gender	0.09*	0.04	.24	0.09	0.04	.24	0.07	0.04	.20
	China years	-0.01	0.02	-.10	-0.01	0.02	-.10	-0.01	0.02	-.07
	L1	-0.06	0.04	-.19	-0.06	0.04	-.19	-0.10	0.05	-.32*
2	PRA				-0.01	0.05	-.01	-0.01	0.05	-.02
3	PA							0.30	0.18	.22
R^2			.07			.07			.10	
Adjusted R^2			.02			.01			.03	
F for change in R^2			--			.01			2.75	

Note. PA=phonological awareness, PRA=phonetic radical awareness. *p<.05.

Character writing (Table 7). Similar regression models were built to predict character writing ability. Age, gender, length of stay in China and L1 background accounted for 7% of the variance in character writing. When phonological awareness was entered in step 2 or step 3, it accounted for 3% of the variance in character writing, and failed to achieve statistical

significance. Phonetic radical awareness did not significantly explain the variance in character writing. In sum, neither phonological awareness (p=.10) nor phonetic radical awareness (p=.85) was a significant predictor in character writing.

4.2 RQ 2: Is phonological awareness mediated by phonetic radical awareness in CLS learners' Chinese character reading and writing skills?

To explore whether phonetic radical awareness mediates the relationships between phonological awareness and character literacy skills, path analysis was carried out using AMOS 23. Path analysis is confirmatory in nature, and it should be based on certain theoretical frameworks or research findings (Klein, 2010; McDonald & Ho, 2002). Drawing on the findings about the influence of L1 background on phonological awareness (Branum-Martin, Tao, & Garnaat, 2015; Zhang, 2017) and the correlation matrix (Table 8) between the measured variables in our study, only L1 background and gender, out of the four background variables, were included in the model.

L1 is assumed to contribute to phonological awareness, rather than phonetic radical awareness, because Arabic and English use alphabetic writing systems and the Arabic and English CSL learners are normally categorized into non-character groups. In addition, gender only significantly correlated with phonological awareness. Therefore, the effect from L1 and gender to phonological awareness was added. In addition, the paths from phonological awareness and phonetic radical awareness to character reading and writing were depicted. Phonetic radical awareness might mediate the effect of phonological awareness on character reading and writing (Ho & Bryant, 1997a, 1997b), thus an effect from phonological awareness to phonetic radical awareness was added. Moreover, an effect of reading to writing was added considering the strong relationship between the two variables in the correlation matrix (Table 8) and in previous research (Graham et al., 2017). However, model 1 (Figure 1) failed to show

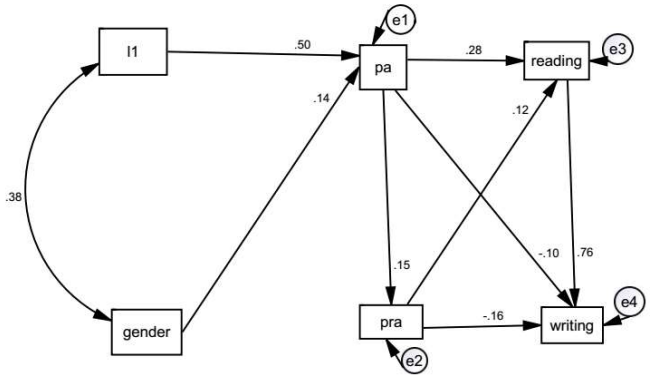
adequate goodness-of-fit indices (Table 9), $\chi 2=18.16$, $p=.006$, RMSEA=.16>.05. Upon further reflection, L1 significantly predicted character writing in the regression analysis (Table 7), thus a direct effect from L1 to character writing was added in Model 2 (Figure 1). Model 2 fits well with the saturated model, with adequate goodness-of-fit indices (Table 9), $\chi 2=5.29$, $p=.38$, RMSEA=.03<.05, and has a lower AIC value in comparison to Model 1.

Seen from Table 10, the total effect of L1 background (β=.15) and phonological awareness (β=.30) on reading was significant, and the total effect of phonological awareness (β=.28) and reading (β=.77) was significant on writing. Phonological awareness had a significant direct effect only on reading (β=.28), not on writing. The direct (β=-.31) and indirect (β=.14) effect of L1 background was significant on writing, so was the direct effect of reading (β=.77). The indirect effect of phonological awareness via reading (β=.21) was also significant on writing.

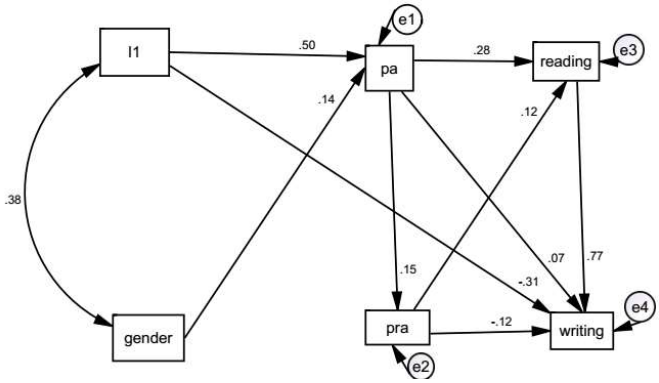
Table 8 Correlation (below diagonal) and covariances (above diagonal) matrix between the measured variables

	L1	Gender	Age	China years	PA	PRA	Reading	Writing
L1	.25	.08	.24	.21	.03	.04	.02	-.01
Gender	.38*	.19	.16	.15	.02	.002	.02	.01
Age	.41*	.31*	1.37	.36	.02	.02	.03	-.01
China years	.40*	.32*	.29*	1.11	.02	.02	.004	-.02
PA	.56*	.33*	.16	.13	.01	.01	.01	.002
PRA	.21	.01	.06	.04	.15	.13	.01	-.003
Reading	.20	.23*	.15	.03	.30*	.16	.02	.02
Writing	-.15	.13	-.05	-.10	.10	-.05	.71*	.02

Note. PA=phonological awareness, PRA=phonetic radical awareness, reading=character reading, writing=character writing. *p<.05.



Model 1



Model 2

Figure 1 Path models for the relationships between L1, gender, phonological awareness (PA), phonetic radical awareness (PRA) and character reading and character writing

Table 9 Summary of the goodness-of-fit indices of Model 1 and Model 2

	$\chi 2$	*df*	*p*	GFI	RMSEA	NFI	RFI	IFI	TLI	CFI	PGFI	AIC
Model 1	18.16	6	.01	.94	.16	.87	.67	.91	.75	.90	.27	48.16
Model 2	5.29	5	.38	.98	.03	.96	.89	1.00	.99	1.00	.23	37.29

Table 10 Decomposition of effects between the measured variables in Model 2

Path	Direct effect				Indirect effect				Total effect				R^2/
	B	SE	β	SE	B	SE	β	SE	B	SE	β	SE	*adjusted* R^2
L1	.12	.02	.50*	.09	-	-	-	-	.12	.02	.50*	.09	.33/.31***
Gender on PA	.04	.02	.14	.08	-	-	-	-	.04	.02	.14	.08	
L1	-	-	-	-	.06	.04	.07	.06	.06	.04	.07	.06	.05/.02
Gender	-	-	-	-	.02	.01	.02	.02	.02	.01	.02	.02	
PA on PRA	.46	.32	.15	.11	-	-	-	-	.46	.32	.15	.11	

L1	-	-	-	-	.04	.02	.15*	.06	.04	.02	.15*	.06	.12/.08*
Gender	-	-	-	-	.01	.01	.04	.03	.01	.01	.04	.03	
PA	.35	.13	.28*	.10	.02	.03	.02	.03	.37	.13	.30*	.10	
PRA on reading	.05	.05	.12	.12	-	-	-	-	.05	.05	.12	.12	
L1	-.10	.03	-.31*	.09	.04	.02	.14*	.06	-.06	.03	-.17	.09	.61/.58***
Gender	-	-	-	-	.01	.01	.04	.03	.01	.01	.04	.03	
PA	.09	.12	.07	.09	.29	.12	.21*	.08	.38	.15	.28*	.11	
PRA	-.05	.03	-.12	.07	.04	.04	.09	.09	-.01	.05	-.03	.12	
reading on writing	.84	.09	.77*	.07	-	-	-	-	.84	.09	.77*	.07	

Note. PA=phonological awareness, PRA=phonetic radical awareness. *p<.05, ***p<.001

Below, the results of this study are discussed in relation to the findings from earlier studies and the research gaps in the literature, as set out in the introduction.

5. Discussion

This study explored the contribution of phonological awareness and phonetic radical awareness to the development of character literacy skills among adult Arabic and English CSL learners (RQ1), as well as the effect of phonetic radical awareness in mediating the relationship between phonological awareness and character literacy skills (RQ2). There are two main findings. Firstly, as in previous research, phonological awareness predicted the acquisition of character reading and writing skills directly or indirectly, but unlike what has been previously reported in the literature, phonetic radical awareness did not significantly predict character reading or character writing skills. Consistent with our hypothesis, the overall findings indicate that phonological awareness might be more critical in comparison to phonetic radical awareness for English- and Arabic-speaking CSL learners in the acquisition of literacy skills. Secondly, inconsistent with our hypothesis and also contrary to earlier findings, phonetic radical awareness might not mediate the effect of phonological awareness on character reading

and writing skills. We discuss these findings in detail below, first according to character reading, and next to character writing.

5.1 Chinese character reading

Both phonological awareness and phonetic radical awareness have been found to be crucial for the development of character reading skills for native Chinese-speaking children and CSL learners (e. g. Song et al., 2015; Tong & Yip, 2014). Our study found that although the relationship between phonological awareness and character reading became weaker when the participants' background variables (such as age, gender, length of stay in China and L1) were controlled for, phonological awareness showed a significant direct effect on character reading in the path analysis. Moreover, phonological awareness accounted for a larger amount of variance in character reading in comparison to phonetic radical awareness. These results are consistent with our hypothesis and suggest that phonological awareness might be important for the Arabic and English CSL learners to access a Chinese character's pronunciation. These results are in line with previous research that reported the significance of phonological processing skills for the acquisition of characters in CSL learners speaking alphabetic L1s (Everson, 1998; Jiang, 2003), who might rely on phonological processing abilities to acquire character literacy skills at the pre-intermediate and intermediate levels. The nature of the syllable-based Chinese character writing system may be the principle reason for this. Although the phonology-orthography correspondence exists at the syllable level in characters, Ho & Bryant (1997a, 1997b) points out that subsyllabic awareness is essential to distinguish characters which have the same phonetic radicals yet different pronunciations (such as 请-qǐng, 晴-qíng and 倩-qiàn), and to make orthographic analogies between compound characters with the same phonetic radical and similar pronunciations. More importantly, this may relate to the Universal Phonological Principle (Perfetti, 2003), i.e. reading in any language

universally requires the mapping between the phonological properties at syllabic or subsyllabic level and the corresponding orthographic properties. These results thus support the idea that the role of phonological awareness in character reading is universally critical for adult CSL learners and Chinese children (Song et al., 2015).

It is surprising to find that phonetic radical awareness did not significantly predict the CSL learners' character reading skills. This result is in conflict with previous finding in CSL learners (Tong & Yip, 2014) and Chinese-speaking children (Ho et al., 2003; Luo et al., 2011; Yin & McBride, 2015). Also, these findings do not support the NCCP framework in which semantic and phonetic radicals play an critical role in character reading for CSL learners (Tong et al., 2015). The main reason for the discrepancy in results may relate to the participants' underdeveloped phonetic radical awareness. The Arabic and English group's performance in the task of pseudo-character naming was below ($t(42)=-2.38$, $p=.02$) and at chance level ($t(39)=.51$, $p=.61$), respectively. These results point to the participants' poor achievement in phonetic radical awareness. The participants had learned Chinese for an average of 1.29 years and therefore might not have achieved the threshold level for the mature development of phonetic radical awareness. They may still be at an accumulation or transition stage (Ke, 1998) where they depend on a holistic strategy in character reading. In fact, the participants did rely on phonetic radical for phonological clues to read character, for instance, some participants read 触(chù) as chóng (虫) or 胁(xié) as bàn (办), indicating that they might already know how to guess the pronunciation of unfamiliar characters by referring to the familiar characters already acquired. However, it is possible that they have yet to realize that the single characters in compound character are phonetic radicals, thus their awareness of the role of phonetic radical in representing the phonological properties of character was still at rudimentary level.

Contrary to our hypothesis, our results did not support the view that phonetic radical

awareness may mediate the relationship between phonological awareness and character reading (Ho & Bryant, 1997a, 1997b). Ho and Bryant claim that the function of phonological awareness in aiding character recognition might be bridged by a phonetic radical which is the only orthographic unit that carries phonological information for the compound character. However, the present study did not find a significant path from phonological awareness to character reading via phonetic radical awareness. First, this finding may be attributed to the CSL participants' underdeveloped phonetic radical awareness in the present study, as noted above. Second, the unreliable mapping between a phonetic radical and the pronunciation of compound character might be another reason. Although most characters are compound in orthographic structure, only 26% of the compound characters share identical syllables with their phonetic radicals (Fan, Gao, & Ao, 1984). Therefore, the role of phonetic radicals might be limited in mediating the relationship between phonological awareness and character reading. Third, the different results might be caused by the differences between our study and Ho & Bryant's studies. For instance, different statistical analysis methods were used in our study (path analysis) and the studies by Ho & Bryant (multiple regression). Path analysis is arguably a more sophisticated method for treating data such as ours, with a particular strength being that it allows for an investigation into potential 'chains of influence' among variables in complex data sets (Steiner. 2005). Another potential reason for differences in our findings may relate to the fact that the participants in the current study also differed in L1 background and Chinese learning experience in comparison to Ho and Bryant's. Our data were collected from adult CSL learners in Chinese-as-foreign-language context, whereas the data of Ho & Bryant's were from Chinese children in Chinese-as-native-language context, thus the two groups differed greatly from each other in the input and output in the Chinese language and characters. In sum, it seems that more studies are needed to explore the relationship between phonological awareness and phonetic radical awareness in character acquisition for CSL learners, using more sophisticated

analysis methods.

5.2 Chinese character writing

The current study did not find that phonological awareness was a significant predictor for character writing, in line with the findings reported by Yeung et al. (2011) and Liu et al. (2016) for Chinese children. The main reason might lie in the morphosyllabic nature of Chinese characters, which have an opaque phonology-orthography correspondence.

As for the lack of a significant effect of phonetic radical awareness on character writing skills among the CSL learners, this finding goes against the results reported by Yin and McBride (2015). As well as the above-discussed reasons concerning the nature of Chinese orthography and the underdeveloped phonetic radical awareness in the Arabic and English CSL participants, another cause for the discrepancy in findings might lie in the complexity of character writing in general. Character writing is an activity of using pen to produce the orthographic representation of character according to the phonological or semantic cues. According to the orthographic autonomy hypothesis, phonological information is not necessarily activated in order to access the orthographic code in the task of spelling (Rapp, Benzing, & Caramazza, 1997). The independent role of orthographic information in facilitating written production has been observed in Chinese characters (Han, Zhang, Shu, & Bi, 2007; Law, Yeung, Wong, & Chiu, 2005; Zhang & Wang, 2016). Phonetic radical awareness is just one part of orthographic awareness of characters, and by itself might not be able to activate the orthographic representation of the compound character for CSL learners with limited L2 proficiency.

Contrary to our hypothesis, our study found that the contribution of phonological awareness to character reading but not writing was mediated by phonetic radical awareness.

The finding that the indirect effect of phonological awareness via character reading was significant on character writing is critical for our understanding of the path in which phonological awareness contributes to the acquisition of character writing skills. First, it may be influenced by the phonological constraints in spelling production in alphabetic and morphosyllabic writing systems (Bonin et al., 2001; Tainturier & Rapp, 2001). Second, the CSL learners' alphabetic L1 background might also account for their dependence on phonological awareness in producing written characters. Drawing on the findings reported in Chinese ESL learners whose spelling skills relate more closely with orthographic awareness than with phonological awareness (Kan, 2011; Zhao, 2011), phonological awareness might be critical for Arabic and English CSL learners in writing characters, especially when their orthographic awareness, such as phonetic radical awareness, is still underdeveloped. Third, although an individual may be able to write character accurately without knowing its pronunciation, successful reading might benefit the production of character writing. This result is in line with classroom practices. A meta-analysis study revealed that reading intervention results in statistically significant effect for spelling skills in English children, and this beneficial impact is maintained over time (Graham et al., 2017).

Our results support the theoretical claims on the role of phonological processing skills in spelling. Both the sublexical (phonology-orthography correspondence) and the lexical route (whole word) appear to contribute to successful spelling (Bonin, Peereman, & Fayol, 2001; Tainturier & Rapp, 2001). Bonin, Meot, Lagarrigue, and Roux (2015) found that spelling to dictation depends heavily on the sublexical route. The involvement of phonological processing skills in spelling has been found in alphabetic (al Mannai & Everatt, 2005; Caravolas, 2004; Moll et al., 2014) and morphosyllabic orthographies (Qu, Damian, Zhang, & Zhu, 2011; Wang & Zhang, 2015). The Chinese character system is syllable-based, thus the sublexical route in writing characters may activate at the syllabic level, and it is reasonable to find that character

writing is facilitated by character reading, which significantly correlates with syllable awareness (e.g McBride-Chang, Chow, Zhong, Burgess, & Hayward, 2005; Shu, Peng, & McBride, 2008; Tong, 2008). Therefore, the syllable-based nature of Chinese characters is likely to be the main reason for the mediating role of character reading in the relationship between phonological awareness and character writing.

Taken together, the results of our study have several theoretical implications. In terms of character reading, first, the results of our study together with the similar findings reported in Chinese children, confirm the importance of phonological awareness in the development of character reading skills, and provide more insightful evidence collected from CSL learners for Universal Phonological Principle (Perfetti, 2003) and Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005). Second, contrary to previous findings about the significant role of phonetic radical awareness in character reading for native Chinese speakers and CSL learners, our study failed to observe similar finding and further suggests that a threshold level of phonetic radical awareness is essential for the initiation of its function in character reading, an issue that has been much less investigated. Third, more importantly, contrary to some researchers' proposals (Ho & Bryant, 1997a, 1997b), our study did not find a mediating role of the phonetic radical in the relationship between phonological awareness and character reading, and this could be attributed to the unreliable mapping between phonetic radical and the whole compound character, and the underdeveloped phonetic radical awareness in the CSL learners.

As regards character writing, consistent with the research by Yeung et al. (2011), the current study did not observe a direct significant relationship between phonological awareness and character writing, suggesting that the role of phonological awareness in character writing might be constrained by the morphosyllabic nature of Chinese characters. Secondly, contra the research results reported for native Chinese children (Yin & McBride, 2015), our study did not

find the significant prediction of phonetic radical awareness in character writing and our results indicate that a threshold level of phonetic radical awareness might be also critical for its function in character writing, similar to its role in character reading. These results provide conflicting evidence for the Obligatory Phonological Mediation Hypothesis in Spelling (Rapp & Caramazza, 1997). Our study appears to be the first to observe a statistically significant indirect effect of phonological awareness via character reading, rather than via phonetic radicals, on character writing. This finding points to the significant correlation between reading and writing in CSL learners and also suggests that CSL learners speaking different alphabetic L1s might indirectly rely on phonological processing skills to succeed in character writing, probably due to the influence of the nature of alphabetic L1s.

On a practical level, these findings have implications for L2 classroom instruction. Although the adult CSL learners may quickly achieve a basic understanding of the orthographic structure of Chinese characters (Nguyen et al., 2016; Tong & Yip, 2014; Wang et al., 2004; Wang et al., 2003; Williams & Bever, 2010), CSL participants' poor performance in the task of pseudo-character naming implies that explicit training on the function of the phonetic radicals in representing the pronunciation of Chinese characters is essential to promote their understanding of the relationship between phonetic radicals and characters, and the application of a phonetic radical to retrieve the phonological information of an unfamiliar character (Jiang & Zhao, 2001; Shen, 2005, 2010; Taft & Chung, 1999; Wang et al., 2004; Zhao & Jiang, 2002).

We are aware that our research has limitations. The first relates to the phonological awareness test. The present study used only an oddity test which might be limited for the comprehensive investigation of phonological awareness. Performance in phonological awareness has been found to differ across the tasks (Lin et al., 2010; Yopp, 1988), thus, different tasks might lead to different results in phonological awareness as well as its

contribution to Chinese literacy skills. The second limitation relates to character reading test, in which the test was stopped after the participants made five errors consecutively. Although a similar practice is commonly used in testing Chinese children and the fact that the materials were arranged from high to low frequency could minimize the underestimation of the participants' character reading skills, it is unclear whether this practice significantly influenced the validity of the test. The third limitation concerns the phonetic radical awareness test. This study used a self-developed task to measure phonetic radical awareness and it included only ten pseudo-characters created from 10 single characters. Whether this test is powerful enough to uncover the CSL learners' phonetic radical awareness needs further exploration. The final limitation is that the sample size in the study is arguably rather small, including only 83 CSL learners, and this might not be adequate for path analysis (Klein, 2010; Stage, Carter, & Nora, 2004). In addition, two categorical variables (L1 background and gender) were included in the model, and the model failed to achieve multivariate normality (kurtosis=-3.37). Thus, larger-scale studies are needed to further explore this issue in CSL learners. We leave these issues for future research.

6. Conclusions

This study examined the role of phonological awareness and phonetic radical awareness in Chinese literacy skills, with an English and an Arabic group of CSL learners. This study is the first step towards enhancing our understanding of the contribution of phonological awareness and phonetic radical awareness to the development of Chinese literacy skills among CSL learners speaking different alphabetic L1s. The results show that the learners' phonological awareness, but not their phonetic radical awareness, predicted the acquisition of character reading and writing skills. Secondly, contrary to earlier research, the learners' phonetic radical awareness did not mediate the effect of phonological awareness on character

reading and writing skills. The results point to the different roles that phonological awareness and phonetic radical awareness play in the development of character literacy skills, and the still unclear relationship between phonological awareness and phonetic radical awareness. These findings are important for understanding the contribution of phonological awareness and phonetic radical awareness to the acquisition of character literacy skills for CSL learners.

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